

NAVAL HEALTH RESEARCH CENTER

***TEN YEARS AND 100,000 PARTICIPANTS LATER:
OCCUPATIONAL AND OTHER FACTORS
INFLUENCING PARTICIPATION IN U.S.
GULF WAR HEALTH REGISTRIES***

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For more than a decade after the gulf War, there has been concern that wartime exposures have resulted in significant morbidity among Gulf War veterans. After the end of the war, the Department of Veterans Affairs (VA) and the Department of Defense (DoD) initiated health registries to provide systematic clinical evaluations of Gulf War veterans who chose to participate. By September 1999, there were 32,876 participants in the DoD Comprehensive Clinical Evaluation Program and 70,385 participants in the VA Gulf War Registry Health Examination Program. Demographic and military service factors were identified as well as potential war-related exposures associated with subsequent registry participation after 10 years of observation. Veterans potentially exposed to oil well fire smoke, those near Khamisiyah, Reserve and National Guard, Army veterans, and veterans in the theater of operations during intense combat periods were most likely to elect to participated in a registry. These findings support the hypothesis that certain occupational factors and wartime exposures may influence subsequent health care-seeking behavior.

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Ten Years and 100,000 Participants Later: Occupational and Other Factors Influencing Participation in US Gulf War Health Registries

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fter more than a decade since one of the briefest, full-scale conflicts in US history, many of the veterans of the Gulf War continue to report a broad range of symptoms and illnesses that some believe are a result of exposures during the war.^{1–3} Public and veteran concerns have prompted extensive investigation into possible causes of these symptoms, but etiologies remain elusive. Although epidemiological studies have found no unusual increases in hospitalizations,^{4–7} mortality due to diseases,^{8,9} or birth defects among live births,¹⁰ several recent studies have demonstrated that Gulf War veterans are more likely to self-report symptoms than their military peers.^{11–18} Efforts to group symptoms or conditions reported by Gulf War-era veterans into a unique syndrome or symptom complexes have been unsuccessful, because the same kinds of symptoms and illnesses also occur in both Gulf War and nondeployed veterans.^{12,19–21}

In response to public and veteran concerns about exposures during the Gulf War, two clinical evaluation programs were initiated in 1992 and 1994 and have been maintained to the present. The Department of Veterans Affairs (VA) Gulf War Health Examination Registry (VA Registry) was initiated on November 4, 1992 and offers a complete physical examination, including basic laboratory tests, to Gulf War veterans who elect to participate. Approximately 70,000 participants had enrolled as of September 1999. The Department of De-

fense (DoD) Comprehensive Clinical Evaluation Program (DoD Registry), initiated on June 7, 1994, offers a systematic medical evaluation to Gulf War veterans still on active duty who choose to be examined at one of 184 medical treatment facilities worldwide; approximately 33,000 participants had enrolled as of September 1999.

These registries have been reviewed and characterized in several published reports.^{22–26} In 1998, Gray and colleagues²⁷ published the first study based on combined information from the two registries. In that report, the authors evaluated potential predictors of registry participation among 74,000 Gulf War veterans and found that participants who were enlisted, in the Army, women, construction workers, hospitalized 12 months before the war, and older were more likely to participate in the registry program. Since that original report, almost 30,000 new participants have joined the registries. In addition, estimates of likely exposure to nerve-agent plumes resulting from the detonation of a cache of weapons at Khamisiyah, Iraq,⁷ and estimates of likely exposure to oil well fire smoke have since been calculated.²⁸ Furthermore, data on a small number of service members who had received anthrax immunization or *Botulinum* toxoid have become available.²⁹ In our expanded analysis, we sought to identify demographic, deployment, and Gulf War exposure variables that may predict registry participation with these new data on occupational and environmental exposures.

Methods

Study Population

Our study population consisted of >100,000 of the nearly 700,000 deployed Gulf War veteran regular active duty, Reserve, and National Guard military personnel who chose to participate in one of the two clinical registries.⁴ Demographic and deployment data for Gulf War veterans

were provided by the Defense Manpower Data Center, Monterey Bay, California, and reflected military status as of August 1, 1991. These data included Gulf War deployment history, number of days deployed to the Gulf theater (categorized by approximate quartiles: 1–92 days, 93–149 days, 150–197 days, and 198–572 days), calendar period in the Gulf theater (August to October 1990, November 1990 to January 1991, February to April 1991, and May to July 1991), gender, marital status (married or not), date of birth (used to categorize by approximate quartile age groups: 17–22 years, 23–25 years, 26–31 years, and ≥32 years), race/ethnicity (white, black, Hispanic, and other), home state (categorized into southeast, southwest, northeast, northwest, and non-US), service branch (Army, Navy, Marine Corps, Air Force, and Coast Guard), service type (active duty, Reserve, and National Guard), DoD primary occupational specialty (ten major groups, defined by the DoD Occupational Conversion Manual),³⁰ rank (enlisted, warrant officer, and commissioned officer), and date of separation from military service.

As in previous reports,^{4,6,31} hospitalization data were obtained from all DoD hospitals from July 31, 1989, to August 1, 1990. These data were linked to our study population and used to create a prewar hospitalization covariate to denote an individual's hospitalization experience during the 12 months before the war.

Oil Well Fire Smoke Exposure Data

More than 600 oil wells were ignited by the Iraqi army as they fled Kuwait in February 1991. The resulting fires burned through November 1991, producing a dramatic visual effect. The global community feared profound changes in meteorological patterns, significant environmental impact, and adverse health effects among those exposed to the smoke and pollution.³² In response, the US

Army Center for Health Promotion and Preventive Medicine, in collaboration with the National Oceanic and Atmospheric Administration/Air Resources Laboratory, estimated 24-hour unit exposures to concentrations of oil well fire smoke particulate matter. These meteorological and diffusion modeling data were then overlaid onto troop location data by using a geographic information system to produce troop exposure estimates.²⁸

Khamisiyah Plume Exposure Data

In March 1991, after the cease-fire was initiated, US troops detonated large munitions caches in southern Iraq. One of these sites, a 40-square-kilometer weapons depot at Khamisiyah, Iraq, was later shown to have contained rockets armed with the nerve agents sarin and cyclosarin. Although there is no evidence that Iraq used chemical or biological weapons during the Gulf War,³³ there was public concern over possible adverse health effects among those exposed to the munitions destruction at Khamisiyah. In 1999, a comparison of the hospitalization experiences in the possibly exposed and unexposed troops was published to address these concerns.⁷ In December 2000, the Office of the Special Assistant for Gulf War Illnesses released a much more detailed report to augment its original 1997 case narrative.³⁴ The revision of the meteorological models; reduction in estimates of nerve agent released; the combining of toxicity levels of both sarin and cyclosarin instead of sarin only; inclusion of atmospheric removal mechanisms, including dilution, deposition, and degradation; and updated unit location and personnel data resulted in a greatly improved model of particulate matter and generally smaller geographic exposure areas than were originally predicted. In our epidemiological study, we have used the revised Khamisiyah exposure data.

DoD Registry Data

The DoD instituted the DoD Registry on June 7, 1994,²² in response to the health concerns of some veterans deployed to the Gulf War. The DoD Registry is a voluntary health registry program established to evaluate Gulf War veterans who have remained on active duty, have retired from service, are currently civilian DoD employees, or are serving full-time in the Reserves or National Guard. In addition, family members of qualified Gulf War veterans or active duty troops who have participated in more recent deployments outside the US are eligible to participate in the DoD Registry evaluation. The main objective of the DoD Registry is to provide a systematic clinical evaluation for the diagnosis and treatment of medical conditions occurring subsequent to service in the Gulf War theater.^{22,23,27,35} The standardized two-phase clinical evaluation includes a comprehensive medical history and a physical examination under the direction of board-certified physicians in either family practice or internal medicine. To facilitate uniform access to care, the program was initiated worldwide at 184 military health care facilities located in 39 states, eight foreign countries, and two territories.³⁶

VA Registry Data

The VA instituted the VA Registry on November 4, 1992, for veterans deployed to the Gulf War who had separated from active duty or who were Reserve or National Guard members. Much like the DoD Registry, the VA Registry is a voluntary program established to offer a complete physical examination with basic laboratory tests, as well as documentation of each participant's medical history. In addition to the Gulf War veterans, family members of some of these veterans also received health examinations. The main objective of the VA Registry is to provide clinical examinations, including both laboratory tests and

physician referrals, to further evaluate symptoms reported by veterans during their initial physical examinations.^{26,37}

Active-duty Gulf War veterans who had left the military or Gulf War veteran Reserve and National Guard members were able to participate in the VA Registry only. Thus, many active-duty personnel were examined first in the DoD Registry, while they were on active duty, and subsequently in the VA Registry, after separation from active-duty military service.

Statistical Analyses

Initial analyses were performed to assess the significance of demographic, exposure, and deployment variables on participation in either registry to evaluate factors that may influence the participation of Gulf War veterans. We retained a set of demographic and exposure variables with *P* values of 0.15 or less for subsequent analyses. Collinearity among variables was evaluated by regression diagnostics. In addition, predictors contributing more than the joint effects were identified by introducing cross-product terms to test for significance of interaction. We used a logistic regression model with a backward, manual, stepwise approach to classify subjects as having an event if they participated in either registry through September 1999. Furthermore, a multivariate, polytomous, logistic regression model was developed to investigate registry-specific participation by studying three categories: DoD Registry participant only, VA Registry participants only, and veterans who chose to participate in both the DoD Registry and VA Registry programs.

Statistical modeling that produced adjusted odds ratios (ORs) and associated 95% confidence intervals (CIs) was performed with SAS software (version 8.0; SAS Institute, Inc, Cary, NC).

Results

Exposure, demographic, and data on registry participation or nonparticipation were available for 678,588 (97.4%) of the 696,534 Gulf War veterans. As of September 1999, a total of 98,835 Gulf War veterans had presented for medical examinations to either health registry and who also had complete exposure and demographic data. Of these registry participants, 29,721 participated in the DoD Registry alone, 66,227 participated in the VA Registry alone, and 2887 were evaluated in both registries.

Chi-square tests revealed the following predictors of registry participation with *P* values of 0.15 or less: number of days deployed to the Gulf theater, calendar period in the Gulf theater, gender, marital status, date of birth, race/ethnicity, home state, service branch, service type, DoD primary occupational specialty, and military rank. Regression diagnostics identified collinearity in the following variables: age and length of service, salary, and rank. As a result, salary and length of service were removed from further analyses.

Logistic regression analyses demonstrated that a number of covariates were associated with participation in either registry: Army (OR = 4.57; 95% CI, 4.44–4.70), age 31 years or older (OR = 2.04; 95% CI, 1.99–2.09), enlisted rank (OR = 2.04; 95% CI, 1.98–2.10), potential exposure to oil well fire smoke (OR = 1.79; 95% CI, 1.70–1.89), Reserve and National Guard status (OR = 1.62; 95% CI, 1.59–1.66), female (OR = 1.33; 95% CI, 1.30–1.37), veterans in theater February through April 1991 (OR = 1.32; 95% CI, 1.26–1.38), craft workers (OR = 1.27; 95% CI, 1.21–1.33), being in theater >198 days (highest quartile) (OR = 1.24; 95% CI, 1.20–1.29), home state not within the United States (OR = 1.23; 95% CI, 1.19–1.27), health care workers (OR = 1.18; 95% CI, 1.13–1.23), and close

TABLE 1

Adjusted Odds Ratios and 95% Confidence Intervals (CIs) From Logistic Regression Modeling for the Outcome of Registry Participation Among Gulf War Veterans

Characteristic	Gulf War Veterans (% of Total)	Registry Participants (% of Total)	Odds Ratio*	95% CI*
Oil well fire				
Not under plume†	66,645 (9.8)	3,102 (3.1)	...	...
Under plume	429,312 (63.3)	77,479 (78.4)	1.79	1.70–1.89
Undefined	182,631 (26.9)	18,254 (18.5)	1.19	1.13–1.25
Khamisiyah plume				
Not under plume†	579,677 (85.4)	74,363 (75.2)	...	...
Under plume	98,921 (14.6)	24,472 (24.8)	1.10	1.08–1.12
Vaccine				
No vaccine or unknown†	670,587 (98.8)	96,868 (98.0)	...	...
<i>Botulinum</i> toxoid	530 (0.1)	88 (0.1)	1.16	0.92–1.48
Anthrax	7,460 (1.1)	1,876 (1.9)	0.91	0.86–0.96
Both	11 (0.0)	3 (0.0)	0.93	0.23–3.77
Gender				
Male†	630,900 (93.0)	88,968 (90.0)	...	...
Female	47,688 (7.0)	9,867 (10.0)	1.33	1.30–1.37
Age at time of deployment (yr)				
<22†	170,560 (25.1)	19,358 (19.6)	...	...
22–25	169,404 (25.0)	20,805 (21.0)	1.06	1.04–1.08
26–31	169,277 (24.9)	24,289 (24.6)	1.31	1.28–1.34
>31	169,347 (25.0)	34,383 (34.8)	2.04	1.99–2.09
Status				
Active duty†	571,690 (84.3)	72,373 (73.2)	...	...
Reserve and National Guard	106,898 (15.7)	26,462 (26.8)	1.62	1.59–1.66
Prewar hospitalization				
No†	637,141 (93.9)	91,851 (92.9)	...	...
Yes	41,447 (6.1)	6,984 (7.1)	1.19	1.16–1.23
Marital status at time of deployment				
Not married†	326,803 (48.2)	41,704 (42.2)	...	...
Married	351,785 (51.8)	57,131 (57.8)	1.07	1.06–1.09
Military pay grade				
Commissioned officer†	65,155 (9.6)	6,322 (6.4)	...	...
Enlisted	604,469 (89.1)	90,924 (92.0)	2.04	1.98–2.10
Warrant officer	8,964 (1.3)	1,589 (1.6)	1.39	1.31–1.48
Total days in theater				
1–92†	171,852 (25.3)	16,266 (16.5)	...	...
93–149	168,074 (24.8)	27,441 (27.8)	1.17	1.14–1.20
150–197	176,794 (26.0)	27,773 (28.1)	1.21	1.18–1.25
198–572	161,868 (23.9)	27,355 (27.6)	1.24	1.20–1.29
Race/ethnicity				
White†	456,745 (67.3)	61,466 (62.2)	...	...
Black	155,589 (22.9)	27,684 (28.0)	1.08	1.06–1.09
Hispanic	24,438 (3.6)	3,017 (3.0)	0.94	0.90–0.98
Other	41,816 (6.2)	6,668 (6.8)	1.20	1.16–1.24
Branch of service				
Navy and Coast Guard†	156,672 (23.1)	6,521 (6.60)	...	...
Army	342,240 (50.4)	75,511 (76.4)	4.57	4.44–4.70
Marines	102,374 (15.1)	10,614 (10.7)	2.64	2.55–2.73
Air Force	77,302 (11.4)	6,189 (6.3)	1.56	1.50–1.61
Home state				
Southwest†	144,419 (21.3)	19,537 (19.8)	...	...
Southeast	139,034 (20.5)	24,405 (24.7)	1.16	1.13–1.19
Northwest	90,795 (13.4)	12,923 (13.1)	1.13	1.10–1.16
Northeast	250,552 (36.9)	36,125 (36.5)	1.10	1.08–1.12
Non-US/unknown	53,788 (7.9)	5,845 (5.9)	1.23	1.19–1.27

proximity to Khamisiyah munitions destruction plumes (OR = 1.10; 95% CI, 1.08–1.12) (Table 1).

Polychotomous modeling revealed that factors associated with registry participation differed by registry

(Table 2). Veterans possibly exposed to oil well fire smoke were more likely to be a participant in both the

TABLE 1—Continued

Characteristic	Gulf War Veterans (% of Total)	Registry Participants (% of Total)	Odds Ratio*	95% CI*
Occupational category				
Electronic equipment repairers [†]	50,397 (7.4)	4,959 (5.0)	...	...
Craft workers	24,902 (3.7)	3,631 (3.7)	1.27	1.21–1.33
Health care	42,737 (6.3)	7,600 (7.7)	1.18	1.13–1.23
Infantry, gun crews, and seamanship	160,998 (23.7)	21,518 (21.8)	1.09	1.05–1.12
Other technical support	14,068 (2.1)	2,507 (2.5)	1.09	1.03–1.15
Electrical/mechanical repair	128,391 (18.9)	16,342 (16.5)	1.06	1.02–1.10
Service and supply handlers	82,780 (12.2)	15,810 (16.0)	1.05	1.01–1.09
Missing	25,944 (3.8)	4,205 (4.3)	1.04	0.99–1.09
Communications and intelligence	62,860 (9.3)	8,723 (8.8)	1.01	0.97–1.05
Nonoccupational	7,204 (1.1)	755 (0.8)	0.99	0.91–1.07
Functional support	78,307 (11.5)	12,785 (12.9)	0.97	0.94–1.01
Time period in theater				
August–October 1990				
Not in theater [†]	367,273 (52.7)	54,899 (54.7)	...	...
In theater	329,261 (47.3)	45,440 (45.3)	0.92	0.90–0.94
November 1990–January 1991				
Not in theater [†]	169,354 (24.3)	17,428 (17.4)	...	...
In theater	527,180 (75.7)	82,950 (82.6)	1.11	1.08–1.14
February–April 1991				
Not in theater [†]	92,405 (13.3)	4,613 (4.6)	...	...
In theater	604,129 (86.7)	95,720 (95.4)	1.32	1.26–1.38
May–July 1991				
Not in theater [†]	423,900 (60.9)	55,442 (55.3)	...	...
In theater	272,634 (39.1)	44,897 (44.7)	0.93	0.92–0.95

Dept of Defense Comprehensive Clinical Evaluation Program health data and the Veterans Administration Gulf War Health Examination Registry data were used.

* Adjusted odds ratio and 95% CI.

[†] The reference category.

DoD and VA Registries, compared with nonexposed veterans (OR = 2.75; 95% CI, 2.01–3.77). Veterans who were at Khamisiyah were more likely to participate in the DoD Registry (OR = 1.14, 95% CI, 1.11–1.17). Reserve and National Guard personnel were less likely to be participants in the DoD Registry only (OR = 0.24; 95% CI, 0.23–0.25). Army service members were more likely to be registered with the DoD Registry alone compared with Gulf War veterans from other service branches (OR = 10.46; 95% CI, 9.83–11.13). Those presenting for hospitalization before the war were more likely to be participants in both registries than either registry alone (OR = 1.30; 95% CI, 1.12–1.50). Finally, the likelihood of being a participant in both the DoD Registry and VA Registry increased with total time in theater (OR from 1.3–1.7).

Discussion

Mortality and morbidity rates of US troops deployed to the Gulf War were significantly lower than in previous full-scale conflicts despite strenuous physical activity, adverse environmental surroundings and exposures, and less-than-ideal psychological conditions.^{38,39} However, as US troops returned from the Gulf region and transitioned from wartime to peacetime, they began to report symptoms and illnesses that they attributed to their Gulf War experiences. To better understand these self-reported symptoms, the DoD and VA initiated clinical evaluation programs to systematically evaluate participants and have enrolled >100,000 Gulf War veterans as of September 1999.

A previous study described demographic factors associated with registry participation in both regis-

tries.²⁷ With more participants and new data on possible occupational and environmental exposures now available, we were able to evaluate the impact of these potential exposures on registry participation after the war. In addition to finding greater odds of participation among personnel who were in the Army, who were Reserve and National Guard, women, had served longer in the Gulf War theater, were older, and in theater during the heaviest fighting, we examined new potential exposure and vaccination data.

Possible nerve-agent exposure data revealed that those personnel presumed to be exposed to the chemical munitions plumes at Khamisiyah were also more likely to present for a medical evaluation at either program than their deployed peers who were not potentially exposed. Increased self-referral for this group might im-

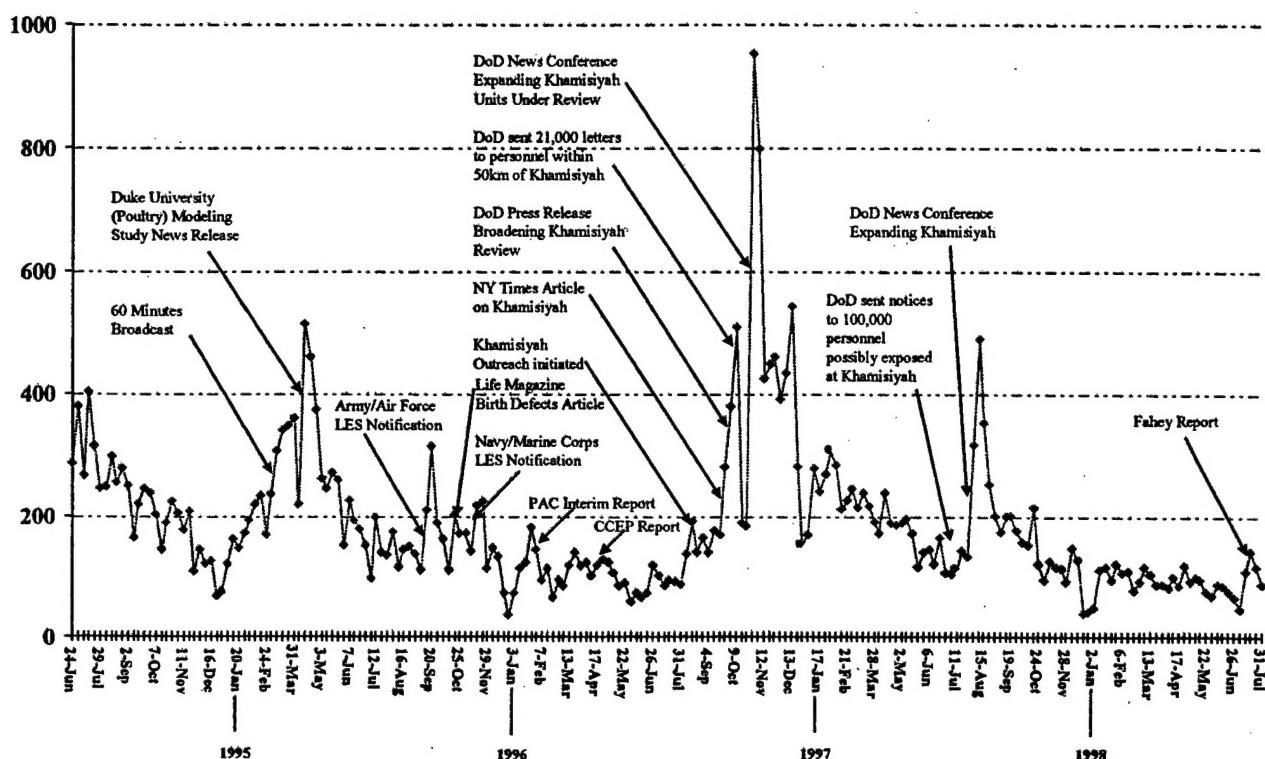


Fig. 1. Chronicle of media reports and Department of Defense (DoD) news releases and reports that may have influenced self-referrals to the DoD Registry for the period of June 1994 through July 1998. PAC, Public Advisory Committee; LES, Leave and Earnings Statements.

ply that exposure to the demolitions at Khamisiyah was associated with more illnesses, although objective measures of illness severe enough to require hospitalization have not been found among this potentially exposed population.⁷ The more likely explanation would be that this increase in participation is the result of DoD and VA notification letters along with possible media influence to persuade veterans who were potentially exposed to the plumes to participate in one of the registries (Fig. 1). Research is currently underway to determine whether there are temporal associations between these notification letters and news events with subsequent participation in one of the registries.

Similarly, oil well fire smoke modeling data revealed that those who were shown to be under the smoke plumes were more likely to present for a medical evaluation at either program than their peers who were not under the plume. Increased self-referral to the registries might

imply that oil well fire smoke exposure was associated with increased morbidity or that there were concerns that exposure may eventually lead to poor health. Such an association has been suggested previously,^{40–43} although objective measures of severe illness leading to hospitalization have not been noted among the smoke-exposed veterans.²⁸ Like Khamisiyah, the increased participation among the potentially exposed veterans may be due to news events or media coverage of the dramatic visual evidence of gross air pollution emanating from the oil well fires.

Immunization data included only documented vaccinations against *Botulinum* toxin and anthrax administered during the Gulf War deployment. It is interesting that exposures to these militarily unique vaccines were not associated with registry participation. It should be noted, however, that databases on vaccine administration in the Gulf War were sparse, so these findings must be

viewed with caution and may not be generalizable.

Investigation of DoD primary occupational specialties found that the broad category of craft workers, including officers who were civil engineers or architects, and enlisted personnel who worked as carpenters, construction equipment operators, metalworkers, machinists, plumbers, welders, electricians, and heating and air-conditioning specialists were the most likely to present for evaluation at either registry. Further analyses with polychotomous modeling revealed that this increase in self-referral was due primarily to an increase in participation in the VA Registry. This finding is consistent with other reports that considered DoD occupational categories^{7,27,28} and reports of increased symptom reporting among Navy construction battalions known as Seabees.^{14,18,21}

Health care providers, including medical personnel who are physicians, dentists, optometrists, nurses, therapists, veterinarians, and phar-

TABLE 2

Adjusted Odds Ratios (ORs) and 95% Confidence Intervals (CIs) From Polychotomous Logistic Regression Modeling for the Outcome of Registry Participation in the Dept of Defense (DoD) Registry and the Veterans Administration (VA) Registry Among Gulf War Veterans

Characteristic	Registry Participation Outcome											
	Nonregistry Participant			DoD Registry and VA Registry Participant			DoD Registry Participant			VA Registry Participant		
	n	n	OR	CI	n	OR	CI	n	OR	CI		
Oil well fire												
Not under plume*	63,543	66	...	...	809	...	...	2,227	...	...
Under plume	351,833	2,360	2.75	2.01–3.77	24,374	1.83	1.66–2.02	50,745	1.80	1.69–1.92		
Undefined	164,371	461	1.51	1.11–2.07	4,538	1.16	1.05–1.28	13,255	1.17	1.10–1.24		
Khamisiyah plume												
Not under plume*	505,304	2,076	...	...	21,409	...	...	50,878	...	...
Under plume	74,449	811	1.09	1.00–1.19	8,312	1.14	1.11–1.17	15,349	1.07	1.05–1.10		
Vaccine												
No vaccine and unknown*	573,719	2,833	...	...	29,376	...	...	64,659	...	...
Botulinum toxoid	442	1	0.61	0.08–4.34	22	2.16	1.40–3.33	65	1.08	0.82–1.41		
Anthrax	5,592	53	0.70	0.53–0.92	323	0.98	0.87–1.10	1,503	0.92	0.86–0.97		
Gender												
Male*	541,932	2,508	...	...	26,763	...	...	59,697	...	...
Female	37,821	379	1.80	1.60–2.03	2,958	1.42	1.36–1.49	6,530	1.29	1.25–1.33		
Age at time of deployment (yr)												
<22*	151,202	307	...	...	4,043	...	...	15,008	...	...
22–25	148,599	341	1.04	0.89–1.22	5,582	1.25	1.19–1.30	14,887	1.00	0.98–1.03		
26–31	144,988	612	1.83	1.58–2.12	9,287	1.97	1.88–2.05	14,390	1.08	1.05–1.11		
>31	134,964	1,627	5.16	4.48–5.95	10,809	2.83	2.71–2.96	21,947	1.74	1.70–1.79		
Status												
Active duty*	499,317	1,882	...	...	27,901	...	...	42,590	...	...
Reserve and National Guard	80,436	1,005	1.80	1.63–1.99	1,820	0.24	0.23–0.25	23,637	2.70	2.64–2.77		
Prewar hospitalization												
No*	545,290	2,680	...	...	27,397	...	...	61,774	...	...
Yes	34,463	207	1.30	1.12–1.50	2,324	1.03	0.98–1.08	4,453	1.28	1.24–1.32		
Marital status at time of deployment												
Not married*	285,099	889	...	...	9,273	...	...	31,542	...	...
Married	294,654	1,998	1.22	1.11–1.34	20,448	1.40	1.36–1.44	34,685	0.95	0.93–0.97		
Military pay grade												
Commissioned officer*	58,833	217	...	...	2,419	...	...	3,686	...	...
Enlisted	513,545	2,594	2.21	1.90–2.56	26,533	1.58	1.50–1.65	61,797	2.30	2.21–2.39		
Warrant officer	7,375	76	1.70	1.30–2.23	769	1.36	1.25–1.49	744	1.25	1.15–1.36		
Total days in theater												
1–92*	155,586	418	...	...	4,457	...	...	11,391	...	...
93–149	140,633	845	1.33	1.15–1.54	7,192	1.12	1.06–1.18	19,404	1.18	1.15–1.22		
150–197	149,021	780	1.50	1.28–1.77	8,241	1.14	1.08–1.21	18,752	1.23	1.19–1.28		
198–572	134,513	844	1.67	1.38–2.01	9,831	1.20	1.12–1.29	16,680	1.22	1.17–1.27		
Race/ethnicity												
White*	395,279	1,690	...	...	16,594	...	...	43,182	...	...
Black	127,905	909	1.16	1.06–1.27	10,248	1.27	1.24–1.31	16,527	0.97	0.96–1.00		
Hispanic	21,421	95	1.06	0.85–1.31	1,170	1.08	1.02–1.16	1,752	0.86	0.81–0.90		
Other	35,148	193	1.23	1.05–1.44	1,709	1.24	1.17–1.31	4,766	1.17	1.13–1.21		
Branch of service												
Navy and Coast Guard*	150,151	119	...	...	1,150	...	...	5,252	...	...
Army	266,729	2,433	6.87	5.66–8.34	25,228	10.46	9.83–11.13	47,850	3.20	3.10–3.31		
Marines	91,760	134	2.15	1.67–2.78	1,503	2.55	2.35–2.76	8,977	2.46	2.37–2.55		
Air Force	71,113	201	2.27	1.80–2.86	1,840	2.81	2.60–3.03	4,148	1.24	1.19–1.29		

TABLE 2—Continued

Characteristic	n	Registry Participation Outcome								
		Nonregistry Participant			DoD Registry and VA Registry Participant			DoD Registry Participant		
		n	OR	CI	n	OR	CI	n	OR	CI
Occupational category										
Electronic equipment repairers*	45,438	148	...	...	1,888	...	...	2,923	...	...
Craft workers	21,271	104	1.25	0.97–1.62	800	0.97	0.89–1.06	2,727	1.42	1.34–1.50
Health care	35,137	247	1.06	0.85–1.31	2,410	1.39	1.27–1.45	4,943	1.15	1.09–1.21
Infantry, gun crews, seamanship	139,480	499	1.01	0.84–1.22	6,827	0.86	0.81–0.91	14,192	1.22	1.17–1.27
Other technical support	11,561	81	1.08	0.82–1.42	942	1.09	1.00–1.19	1,484	1.08	1.01–1.16
Electrical/mechanical repair	112,049	454	1.03	0.85–1.25	5,197	0.94	0.89–1.00	10,691	1.13	1.08–1.18
Service and supply handlers	66,970	510	1.00	0.83–1.22	3,229	0.79	0.75–0.84	12,071	1.19	1.14–1.24
Missing	21,739	144	1.17	0.93–1.49	1,008	0.88	0.81–1.96	3,053	1.12	1.06–1.18
Communications/intelligence	54,137	225	0.94	0.76–1.17	3,121	0.89	0.83–0.94	5,377	1.08	1.03–1.13
Nonoccupational	6,449	20	1.13	0.71–1.82	220	0.90	0.78–1.04	515	1.06	0.96–1.17
Functional support	65,522	455	0.97	0.80–1.17	4,079	0.87	0.82–0.93	8,251	1.03	0.98–1.08
Home state										
Southwest*	124,882	563	...	...	6,034	...	...	12,940	...	...
Southeast	114,629	836	1.21	1.08–1.35	7,906	1.16	1.11–1.20	15,663	1.15	1.12–1.18
Northwest	77,872	330	1.05	0.91–1.21	3,108	0.93	0.89–0.97	9,485	1.22	1.19–1.26
Northeast	214,427	996	1.04	0.94–1.16	10,484	1.00	0.97–1.04	24,645	1.13	1.11–1.16
Non-US/unknown	47,943	162	1.20	1.00–1.44	2,189	1.21	1.14–1.27	3,494	1.24	1.19–1.29
Time period in theater										
August–October 1990										
Not in theater*	298,840	1,697	...	...	13,483	...	...	38,583	...	...
In theater	280,913	1,190	0.82	0.72–0.94	16,238	0.86	0.82–0.90	27,644	0.99	0.96–1.02
November 1990–January 1991										
Not in theater*	142,122	490	...	...	4,316	...	...	12,257	...	...
In theater	437,631	2,397	1.06	0.93–1.21	25,405	1.14	1.08–1.20	53,970	1.08	1.05–1.11
February–April 1991										
Not in theater*	78,969	133	...	...	1,032	...	...	3,338	...	...
In theater	500,784	2,754	0.91	0.72–1.14	28,689	1.57	1.43–1.71	62,889	1.24	1.18–1.30
May–July 1991										
Not in theater*	355,895	1,434	...	...	17,361	...	...	35,975	...	...
In theater	223,858	1,453	0.98	0.90–1.08	12,360	0.89	0.86–0.92	30,252	0.97	0.95–0.99

* The reference category among covariates.

macists, and enlisted military members who are medical laboratory technologists, radiological technologists, emergency medical technicians, dental assistants, optical assistants, pharmaceutical assistants, sanitation specialists, and veterinary assistants, were also more likely to present for evaluation at either registry. Further analysis yielded similar increased odds of participation in both registries or either registry alone. This finding is consistent with other reports of DoD occupational

categories, suggesting that health care workers may have easier access to health care and exhibit more health care-seeking behaviors.^{7,27,28}

Those whom many would consider the "classic" warriors, ie, infantry, gun crews, and seamanship specialists, were also more likely to be a participant in either registry. Further analysis found this increase could be explained by self-referral to the VA Registry, with no increase in the likelihood of participation in the DoD Registry. Furthermore, other

technical and allied specialty occupations, electrical and mechanical equipment repair occupations, and service and supply handler occupations were at slightly increased odds of participation in either registry. Further study of the subtle differences in health care utilization among these military populations may be useful.

Unique to our analyses, we were able to investigate which factors were associated with participation by specific health registry. Those under

the oil well fire smoke plume were more likely to participate in both the DoD and VA Registries rather than either registry alone. As previously noted, perceived exposure(s) may increase the likelihood of presenting for evaluation at a health registry before discharge from military service (Fig. 1) and again after discharge from military service to ensure future medical benefits. This is consistent with the finding that those personnel in close proximity to the Khamisiyah munitions plumes were slightly more likely to be registered with the DoD Registry, possibly as a result of the intense media coverage of the Khamisiyah investigation while many of the personnel were still on active duty.^{27,44,45} Another finding from the polychotomous model was that Army members, compared with other military personnel, were more likely to choose to be part of the DoD Registry than the VA Registry. The finding that Reserve and National Guard personnel were more likely to register with the VA Registry is consistent with the fact that this population does not have access to routine DoD health care. Our finding that those who were hospitalized before the war were more likely to be participants in both registries, rather than either alone, is consistent with the hypothesis that this subgroup may be prone to more health care-seeking behavior in general or to be more worried about their health. Prior hospitalization has been consistently noted as a significant predictor of increased postwar morbidity, resulting in additional hospitalizations in DoD military treatment facilities.^{4,6,7} To understand whether or not Gulf War service resulted in the exacerbation of existing illnesses or conditions in the subgroup with prior hospitalizations, we are further investigating the hospitalization experience of this group of individuals.

It is important to note that the factors included in the polychotomous model—oil well fire smoke and Khamisiyah plumes, anthrax

vaccination, gender, age, prewar hospitalization, military pay grade, number of days in theater, branch of service, home state, and time period in theater—were consistent with respect to the magnitude of the ORs. One would expect relatively consistent ORs for factors that influence participation if the registry populations were homogenous. However, this trend was not seen for factors such as Reserve and National Guard status, in which case they were directed to the VA Registry, nor for the very small group of personnel who received the *Botulinum* toxoid. Likewise, inconsistent ORs for marital status, race/ethnicity, craft workers, infantry and gun crews, service and supply handlers, and communications and intelligence personnel are difficult to explain and do not support homogeneity in the registry populations.

There are some limitations to our analyses. Because of the extensive, global Gulf War veteran outreach effort by both DoD and VA officials, all Gulf War veterans with health concerns or questions were encouraged to report for evaluation whether or not they were ill. Overall, 1 of 7 Gulf War veterans chose to participate. As a result, we cannot draw any conclusions about the overall health status of either the participants or the whole Gulf War-deployed population. Moreover, acquiring precise and reliable exposure data at the individual level is one of the most challenging aspects of epidemiological studies that include potential environmental risk factors. Although the exposure data that we incorporated into our current investigation are the best available data for those specific exposures, these data must be viewed with caution. Moreover, we were not able to account for many other possible exposures. Furthermore, the media focus on possible exposures that may have occurred during the Gulf War likely had a significant impact on registry participation. Although currently being examined by other investigators,

no quantifiable measures of media influence are yet available.

Our study has a number of strengths. The use of sophisticated modeling techniques to quantify the odds of individual registry participation allowed us to analyze factors that influence participation while simultaneously adjusting for other influential factors. Additionally, the large study population permitted robust OR estimates and considerable statistical power to detect small differences across demographic and possible exposure groups. Our long observation period, which considered registry participation for almost >10 years since the Gulf War, likely includes nearly all veterans who desired evaluation. Furthermore, although previous studies demonstrated that some Gulf War veterans were more likely to report chronic symptoms, this study is the first to demonstrate, with objective exposure data, the association of specific potential Gulf War exposures with health registry participation.

In summary, our large case series of >100,000 active-duty military, veteran, National Guard, and Reserve personnel for more than nearly a decade of observation has demonstrated important independent factors associated with postwar participation in Gulf War health registries. Most likely to participate were Army personnel (OR = 4.6), Reserve and National Guard personnel (OR = 1.6), personnel aged 31 years or older (OR = 2.0), female personnel (OR = 1.3), personnel thought to be in the vicinity of oil well fire smoke (OR = 1.8), personnel potentially exposed to the Khamisiyah plume (OR = 1.1), and personnel in theater during the fighting (OR = 1.3). In contrast, those exposed to anthrax vaccine and *Botulinum* toxoid were found not to be more likely to enroll in the registries. Identification of these predictors for registry participation may help the military better understand the specific demographic and military service characteristics and wartime exposures that could

result in increased self-reported symptoms, as well as increased health care-seeking behavior after deployment. Given the large numbers of registry participants and the 10-year observation period, we have presented a fairly robust profile of those individuals most likely to voluntarily participate in a clinical registry program. This information must be tempered by the knowledge that the establishment of the two clinical registry programs itself encourages health care-seeking behavior; that access to care is increased for those eligible; that the existing system of entitlements encourages health care utilization and evaluation of eligibility for service-connected benefits; and that the prevailing public perception of Gulf War health risks based on media coverage of war-related events raises the anxiety level of those potentially exposed. Better health risk communication efforts aimed at the media and the general public, as well as active-duty and veteran populations, postdeployment debriefing programs, and/or greater access to postwar counseling may mitigate some of the health consequences attributed to war-related experiences, particularly among certain subpopulations.

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